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Waterborne Disease Outbreaks - 1946-1980
A Thirty-Five-Year Perspective

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Cincinnati, OH

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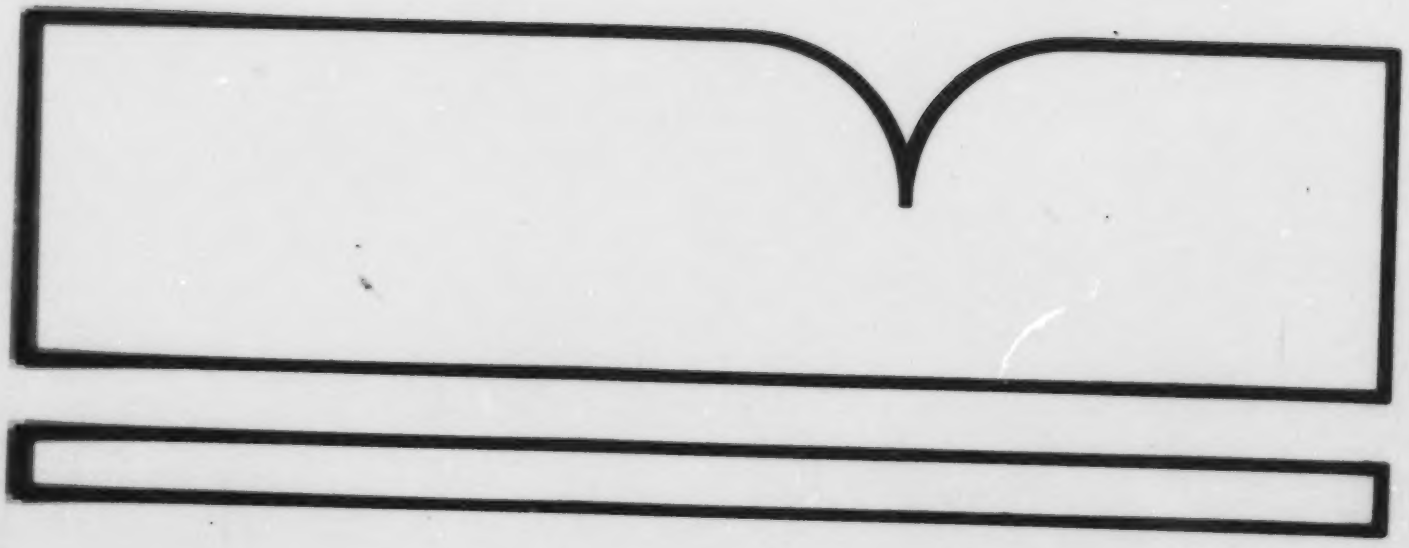

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16. ABSTRACT

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JOURNAL ARTICLE

Waterborne Disease Outbreaks—1946-1980: A Thirty-Five-Year Perspective

Edwin C. Lippy and Steven C. Waltrip

The 672 outbreaks of waterborne disease that were reported in the United States between 1946 and 1980 affected more than 150 000 persons. An analysis of the data from these outbreaks provides information on how often and where outbreaks occurred, as well as on what caused them.

Information on waterborne disease outbreaks has been collected since 1920 and published in summary fashion for the periods 1920-36,[1] 1938-45,[2] 1946-60,[3] 1961-70,[4] and 1971-78.[5] Outbreak information on file by year dating back to 1946 was recently entered into an automatic data processing system that provided rapid recall of data for analyses of occurrence, distribution, and trends and for other statistical interpretation. The data for 1946-80 are presented in this article to give a 35-year perspective on waterborne illness associated with drinking water.

Information on waterborne illness has been submitted voluntarily to the US Public Health Service (USPHS) since 1920 by state agencies concerned with intestinal illness. What originally began as a concern for morbidity and mortality resulting from typhoid fever and infant diarrhea and their relationship with food, milk, and water led to the development of important public health measures that had a profound influence on decreasing the incidence of enteric diseases. The voluntary reporting procedure was changed somewhat after the responsibility for it was transferred in 1966 from the National Office of Vital Statistics to the Centers for Disease Control (CDC), which began contacting state health agencies on a yearly basis for reports of disease outbreaks. In 1971 the US Environmental Protection Agency (USEPA) joined with CDC in a collaborative effort to improve reporting of waterborne illness by contacting state regulatory agencies responsible for water supply activities. A form was developed to provide detailed information on waterborne outbreaks, and its use was initiated in 1976 after two years of field testing. Reporting was further refined in 1978 when annual summaries of waterborne outbreaks were separated from those caused by food and published under the title "Water-Related Disease Outbreaks."[6]

Authors involved in writing summaries and articles on waterborne disease outbreaks have been critical in their appraisal of the effectiveness of voluntary reporting. They indicate that it is a passive surveillance system which detects only a fraction of the outbreaks and cases of illness that occur each year in the United States. In support of this criticism are the statistics developed from an improved surveillance system in one state that accounted for 48 of the 189 outbreaks or 25 percent of the total reported in the period from 1976 to 1980. Craun and McCabe,[7] in a review spanning 1946-60, estimated that one half of the outbreaks in community systems and only one third in noncommunity systems are reported. Information from a study done in a Rocky Mountain state under auspices of a USEPA contract showed that under intensified surveillance efforts, the annual number of outbreaks increased nearly fourfold in a three-year period compared with the occurrence in the previous three years. Surveillance and reporting efforts improved from 1971 to 1980 (Figure 1), but much more needs to be done.

The analyses that follow must be interpreted with caution because the intensity of surveillance varies among states. Agencies that conscientiously report outbreaks may cast doubt on the safety of drinking water in their states although this may not be warranted. If all states placed equal emphasis on surveillance, a more accurate representation of occurrence, distribution, and trends could be presented.

The data presented in this article are from outbreaks associated with water obtained from public or individual water systems and intended for drinking or domestic purposes. At least two cases of acute infectious disease or one case of an acute intoxicating illness must occur and originate from a common source to

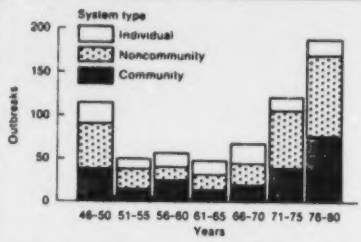

Figure 1. Occurrence of waterborne disease outbreaks by five-year increments

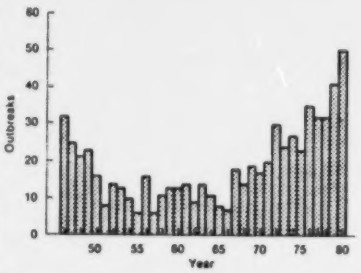

Figure 2. Annual occurrence of waterborne disease outbreaks

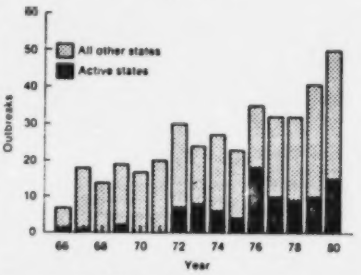

Figure 3. Waterborne disease outbreaks in two active states versus those in all other states

TABLE 1

Occurrence of waterborne disease outbreaks by type of water system

System Type	Outbreaks		Occurrence per 1000 Systems*
	1946-80	1971-80	
Community	237	121	1.9 (121/65)
Noncommunity	296	157	1.0 (157/150)
Individual	137	36	
Unknown	2	0	

*1971-80 data

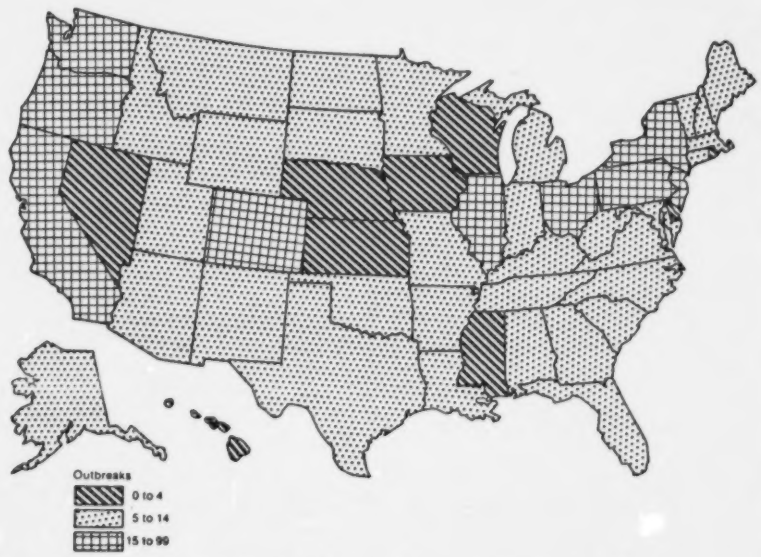

Figure 4. Geographic distribution of waterborne disease outbreaks

qualify as an outbreak. An infectious disease that produces symptoms affecting the upper and lower gastrointestinal tract is caused by a microbiological agent and is accompanied by an incubation period ranging from about 24 hours to several weeks. An intoxicating illness that produces symptoms associated with the upper gastrointestinal tract is caused by a chemical agent, and the incubation period from exposure to illness is brief—usually a matter of a few hours. For one case of illness to qualify as an outbreak associated with a chemical agent, the causative agent must be identified in a sample of water collected from the system.

A public water system normally consists of (1) a water supply from a surface source (e.g., river, lake, reservoir), a ground source (e.g., well, spring, or a mixture of the two); (2) treatment facilities (e.g., filtration, disinfection); and (3) a distribution network of mains and pipes that deliver water to the consuming public. Unfortunately, many systems have no treatment facilities. By definition, public water systems also have at least 15 service connections and provide water to 25 persons. There are two types of public water systems. A community water system serves year-round residents; a noncommunity water system, which does not meet the residence requirement, serves the traveling public at institutions, camps, parks, or motels. Where public water systems are not available, people develop their own household water supplies—individual systems.

Public water systems currently number about 215 000, with 65 000 community systems serving a resident population of 195 million persons. Noncommunity systems number 150 000, and about 10 million individual systems serve 35 million persons.

Occurrence, distribution, and trends

Outbreaks. Figure 2 illustrates the annual frequency of the 672 waterborne outbreaks reported for the 35-year period commencing in 1946. The trend in number of outbreaks has been increasing since 1966. The trend is even better exemplified in Figure 1 and is especially notable since 1971, when the current system of reporting was established. Figure 2 shows a peak in 1980; the 50 reported outbreaks were the third highest number of outbreaks since record collection began in 1920. The record of 60 outbreaks was reported in 1941. Cursory examination of Figures 1 and 2 indicates that outbreaks were under control for the 1951-70 period, whereas the opposite may be said about the outbreaks for 1971-80. A four-year cycle in annual occurrence began in 1972, with peaks following in 1976 and 1980. There is no obvious scientific explanation for the cycle; however, if it and the current trend continue, 95 outbreaks can be expected in 1984. Again, Figure 2, as well as subsequent analyses, must be tendered with cautious interpretation. Although Figures 1 and 2 show large increases in the number of reported outbreaks for the 1971-80 period com-

pared with those in previous years, relatively few outbreaks were reported by the 50 states. The 50 outbreaks reported in 1980 averaged one per state. If a few states become aggressive in investigating and reporting waterborne outbreaks, the trend can easily be affected. The influence of two such states is shown in Figure 3.

The geographic distribution of outbreaks is shown in Figure 4. Delaware was the only state that did not report an outbreak. States in which the reported outbreaks were low are clustered in the upper Midwest or Plains states, and those in which the number was high are clustered in the eastern United States (New York, Pennsylvania, New Jersey, and Ohio) and in the western United States (Washington, Oregon, and California). The combination of a low population density and a long distance between sources of water supply and wastewater discharge locations may explain the low-outbreak cluster, whereas opposite conditions may explain the high-outbreak clusters. The clusters may also be due to the effort devoted to surveillance of outbreaks. New York has been active in investigating and reporting since the 1940s, and Pennsylvania began a more active effort in the 1970s (Figure 3).

The gross distribution shown in Figure 4 was corrected for population density by expressing the information as a rate—outbreaks per number of community water systems—for each state (Figure 5). Outbreaks in noncommunity and individual systems were not included in the distribution. In Figure 5 the rate of occurrence is based on the number of outbreaks that occurred over the 35-year period for each state and the number of water systems that were counted during a nationwide inventory in 1963.[8] The 1963 date represents a near midpoint in the set of outbreak data.

Of those states in the high-outbreak category of the gross distribution shown in Figure 4, only New York, Colorado, and Oregon remain in the high-outbreak category of the distribution based on the number of water systems (Figure 5). These three remaining states share the high category in the rate distribution with the states of Vermont, New Hampshire, Connecticut, Rhode Island, South Carolina, Wyoming, Idaho, and Alaska. The preponderance of the states in the low-rate category are located in the mid-continental United States. The topic of geographic outbreak clustering is also considered in the section on "Water System Deficiencies."

A temporal distribution of outbreaks, which is given in Figure 6, shows that a peak is evident in the summer months. Summer is also the period of the year for vacations, including visits by many people to recreational areas that are primarily served by noncommunity water systems. Figure 7 was developed to compare the monthly distribution of outbreaks by type of water system. The pronounced peaks shown in this figure indicate that noncommunity systems experience problems in the summer. A similar, clearly defined, temporal distribution is not apparent for community systems.

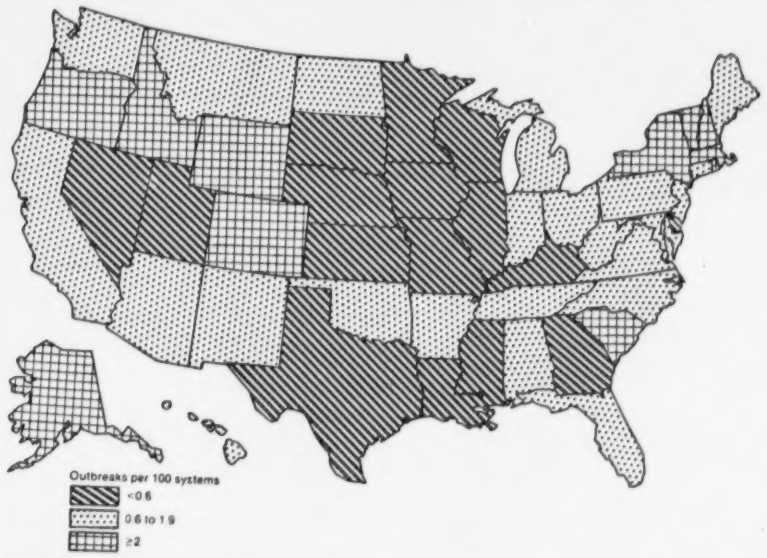

Figure 5. Geographic distribution of waterborne disease outbreaks per 100 community water systems

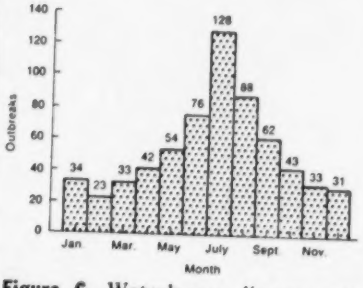

Figure 6. Waterborne disease outbreaks by month *(month not known for 25 outbreaks)*

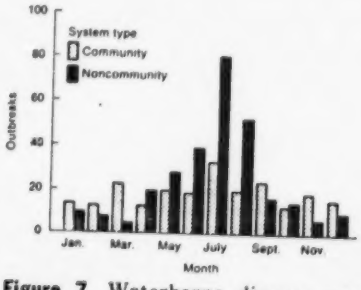

Figure 7. Waterborne disease outbreaks for community and noncommunity systems

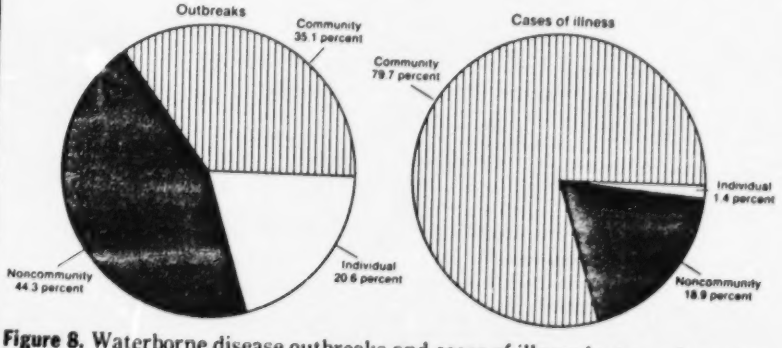

Figure 8. Waterborne disease outbreaks and cases of illness by type of system

Outbreaks in noncommunity systems outnumbered those in community systems, as shown in Table 1 and Figure 8. However, when the rate of occurrence was based on the number of outbreaks per 1000 community or noncommunity systems, the rate for community systems was nearly twice that for noncommunity systems (Table 1). Rates were computed

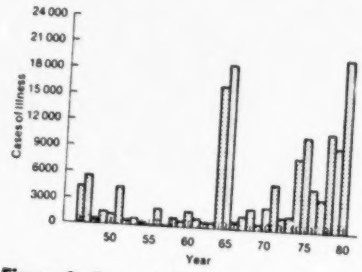

Figure 9. Cases of illness

TABLE 2
Causative agents of waterborne disease

Agent	Outbreaks	Cases of Illness
Bacterial		
Campylobacter	2	3 800
Pasteurella	2	6
Leptospira	1	9
Escherichia coli	5	1 188
Shigella	61	13 089
Salmonella	75	18 590
Total	146	36 682
Viral		
Parvoviruslike	10	3 147
Hepatitis	68	2 262
Polio	1	16
Total	79	5 425
Parasitic		
Entamoeba	6	79
Giardia	42	19 734
Total	48	19 813
Chemical		
Inorganic	29	891
Organic	21	2 725
Total	49	3 616
Unknown	350	84 939
Grand total	672	150 475

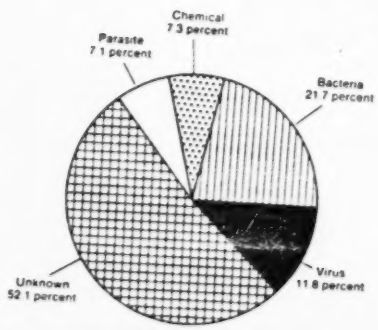

Figure 12. Waterborne disease outbreaks by causative agent

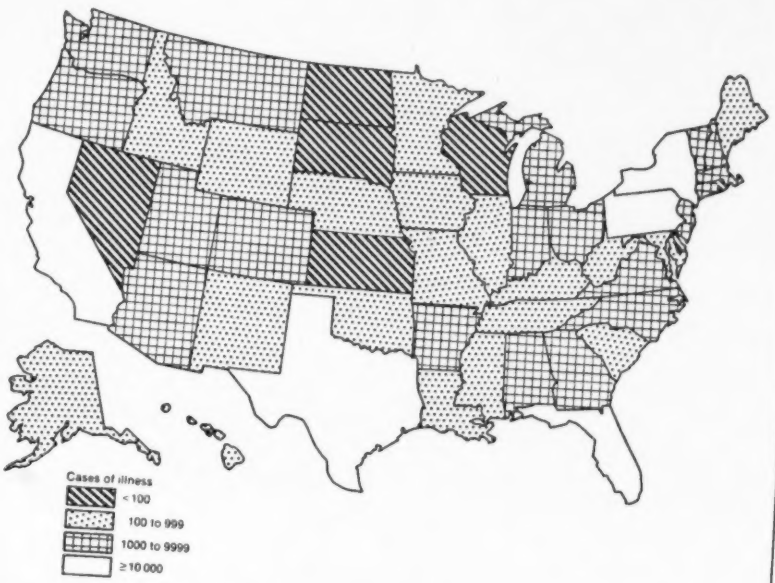

Figure 10. Geographic distribution of cases of illness

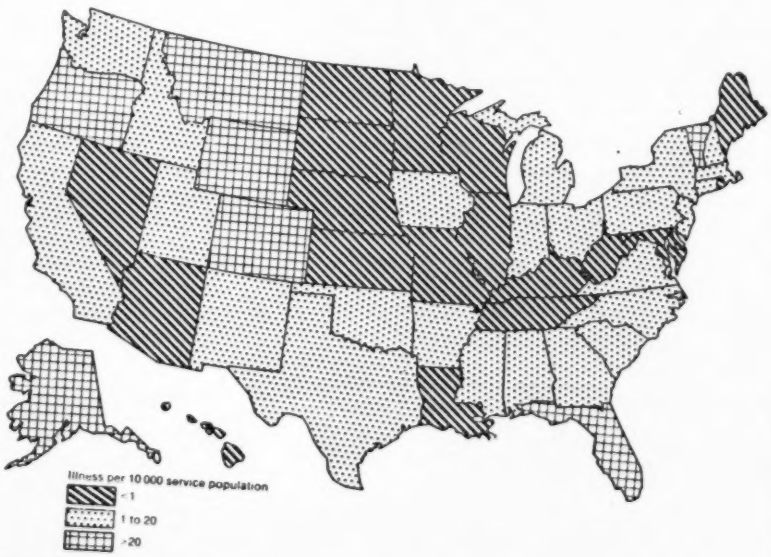

Figure 11. Geographic distribution of cases of illness per 10 000 service population in community water systems

only for the 1971–80 period, to take advantage of information recently collected on the number of water systems in the United States through the Federal Reporting Data System (FRDS). Because national inventories prior to the FRDS did not discriminate between community and noncommunity systems, rates for 1946–80 could not be calculated.

Compared with the outbreak rate for noncommunity systems, the greater rate for community systems is probably due to better reporting of outbreaks; clusters of illness would be more readily recognized and reported in a resident population than in a nonresident population. Travelers exposed to contaminated water from a noncommunity system may become ill some time after exposure (the incubation period) and at a distance from the point of exposure. Associating their illness with contaminated water served at a motel, campground, or restaurant that they visited two to three days previously would be difficult. If an association would be perceived, the separation by time and distance might tend

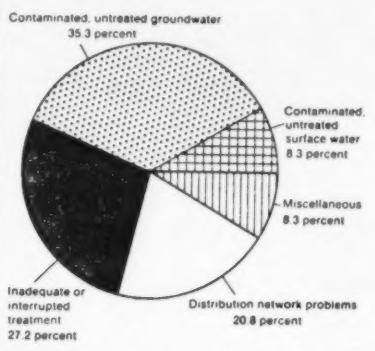

Figure 13. Waterborne disease outbreaks by deficiency in public water systems

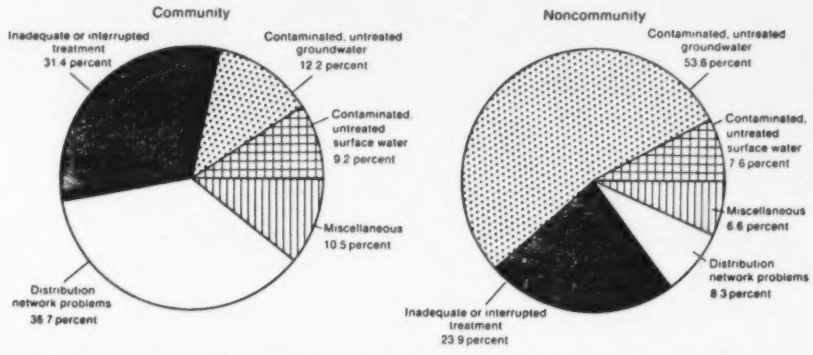

Figure 14. Waterborne disease outbreaks by deficiency in community and noncommunity water systems

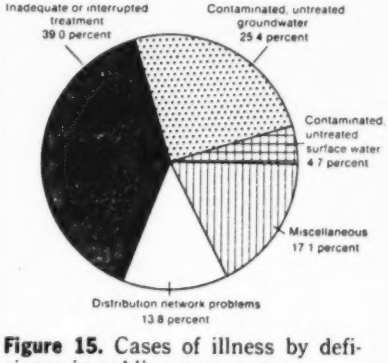

Figure 15. Cases of illness by deficiency in public water systems

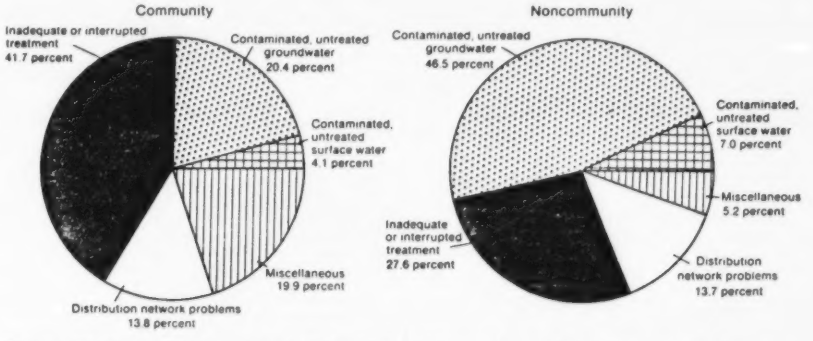

Figure 16. Cases of illness by deficiency in community and noncommunity water systems

to make people want to forget the event and not become involved with reporting an illness potentially related to contaminated drinking water. Therefore, although the outbreak rates are greater for community systems than for noncommunity systems, the recognition and reporting of outbreaks in noncommunity systems must be acknowledged as affecting the rates.

Illness. The annual occurrence of cases of illness associated with waterborne disease outbreaks are shown in Figure 9. The total number of cases during the period was 150 475. More than 20 000 cases occurred in the peak year of 1980, with four major outbreaks accounting for 14 000 of these cases. The prominent peaks in two other years, 1964 and 1965, each resulted from one major outbreak that caused 16 000 cases of illness. Excluding these two years, illness could be labeled as insignificant for a 25-year period. Since 1974, however, the number of cases has increased dramatically and been accompanied by a similar increase in outbreaks (Figures 1 and 2).

The geographic distribution of illness is shown in Figures 10 and 11. Figure 10 represents a gross distribution of all cases. Figure 11 shows a distribution that was corrected for population density by expressing illness as a rate based on the number of people served by community water systems. Those cases attributable to outbreaks in noncommunity and individual systems were not considered in the rate. In Figure 11 the rate is based on the number of cases per 10 000 service population counted during the USPHS national inventory in 1963.

The gross distribution emphasizes the large outbreaks that occurred in California (Riverside with 16 000 cases in 1965), Texas (Georgetown with 8000 cases in 1980), Florida (Gainesville with 16 000 cases in 1964), Pennsylvania (Sewickley with 5000 cases in 1975 and Bradford with 3500 cases in 1979), and New York (99 outbreaks, the largest of which was in Rome with 4800 cases in 1974). In Figure 11, the use of a rate to portray illness changed the distribution pictured in Figure 10, with only Florida remaining in the high-rate category and being joined by Oregon, Montana, Wyoming, Colorado, Vermont, and Alaska.

Figure 12 indicates that bacterial agents were a major factor among outbreaks. In more than half of the outbreaks, however, an agent was not determined. Microbiological agents are rarely identified in water (<1 percent of outbreaks) but are determined through collection and assay of stool or blood specimens. The lack of success in identifying agents in water stems mainly from the lack of local capability to isolate, culture, and identify microorganisms from an environment in which they are normally reduced in number by dilution or die away as opposed to medical specimens collected from a human subject in which agents are propagated. Another reason for poor success with environmental samples is that outbreaks are normally recognized one to two weeks after the exposure, which allows ample time for the water system to be purged of contamination through normal usage of water. Conversely, opportunities for identifying the agent in medical specimens are better because of secondary transmission of illness through person-to-person pathways. A person originally exposed to the agent in his drinking water may transmit the disease some days later to a contact who then becomes a positive candidate for investigators. Because some agents survive freezing, contaminated water drawn from the tap and frozen as ice cubes for later use can also be analyzed and used to supplement the analysis of medical specimens.

Chemical agents can affect aesthetic qualities of water. Unusual taste, odor,

TABLE 3

Comparison of sources of water supply[7] for community water systems with low and high outbreak rates

Outbreak Rate	State	Systems Using Surface Sources	Systems Using Ground Sources	Ratio of Ground to Surface Sources
Low	Delaware	5	36	7.2
	Georgia	80	327	4.1
	Illinois	118	786	6.7
	Iowa	33	666	20.2
	Kansas	73	400	5.5
	Kentucky	130	123	0.9
	Louisiana	43	235	5.5
	Minnesota	23	578	25.1
	Mississippi	3	230	76.7
	Missouri	87	341	3.9
	Nebraska	3	427	142.3
	Nevada	9	43	4.8
	South Dakota	11	237	21.5
	Texas	172	960	5.6
	Utah	32	249	7.8
	Wisconsin	21	404	19.2
	Total	843	2661	*
High	Alaska	25	11	0.4
	Colorado	92	196	2.1
	Idaho	32	147	4.6
	Massachusetts	54	168	3.1
	New Hampshire	50	52	1.0
	New York	296	653	2.2
	Oregon	123	197	1.6
	Rhode Island	8	35	4.4
	South Carolina	63	148	2.3
	Vermont	41	116	2.8
	Wyoming	27	69	2.6
	Total	811	1792	†

*Median ratio = (6.7 + 7.2)/2 = 6.95
†Median ratio = 2.3

or discoloration leads to complaints that prompt collection of samples and investigation by local authorities. Outbreaks and illness caused by chemicals are probably better recognized and reported than are those caused by microbial agents. Table 2 lists microbiological and chemical agents responsible for outbreaks from 1946 to 1980.

Cases of illness are classified according to type of water system in Figure 8. Although noncommunity systems have the largest percentage of the total number of outbreaks, cases of illness in community systems greatly outnumber those occurring in other water systems. Simply stated, outbreaks in community systems are more serious in terms of illness because of the availability of a resident population to become infected. The severity of illness in community or noncommunity systems is further exemplified by comparing cases per outbreak. Community systems averaged 506 cases of illness per outbreak, and noncommunity systems averaged 96 cases, which gives a severity factor of five.

The number of deaths resulting from waterborne outbreaks has greatly diminished over the years. From 1920 through 1945, 960 deaths were reported (mostly from typhoid fever), for an annual rate of 37. During the 35-year period since 1946, the rate has been reduced to 1 death per year. An underreporting problem probably exists in terms of deaths associated with gastrointestinal illness, which can stress a weakened cardiovascular system or other critical body function. That is, even though mortality occurs in the weakened and distressed population affected by gastrointestinal illness, the death is not attributed to gastrointestinal illness.

Water system deficiencies

Deficiencies in water system design, operation, and maintenance that contribute to waterborne outbreaks are of importance to regulatory agencies and to the water utility industry, including purveyors, equipment manufacturers, consulting firms, and laboratories. Overwhelming percentages of a certain deficiency are indicative of a breakdown in an approach by a regulatory agency or the industry. Unfortunately, the analyses that follow show that the causes of outbreaks for 1946 to 1980 do not markedly differ from those presented in summaries for 1920 to 1945, which may indicate that drastic changes are needed in attitudes of regulatory agencies and the industry.

Water system deficiencies that caused or contributed to outbreaks were categorized under five major headings as follows:

1. Use of contaminated, untreated surface water;
2. Use of contaminated, untreated groundwater;
3. Inadequate or interrupted treatment;
4. Distribution network problems; and
5. Miscellaneous.

Use of contaminated, untreated surface water and groundwater is self-explanatory. Inadequate or interrupted treatment includes breakdown or failure of equipment, insufficient chlorine contact time, and an overloaded process. Distribution network problems include cross-connections, improper or inadequate main disinfection, and contamination of open distribution reservoirs. The miscellaneous category encompasses deliberate sabotage, events that systems are not expected to cope with, and undetermined causes of outbreaks.

Water system deficiencies that caused or contributed to outbreaks are graphically depicted by the five categories in Figure 13. Outbreaks in individual systems were omitted so that deficiencies in public water systems, which are regulated by a federal law, could be emphasized. Use of untreated, contaminated groundwater and poor practices in treatment and distribution of water are deficiencies that deserve attention. More than 80 percent of the outbreaks were associated with these deficiencies. The deficiencies in community and noncommunity systems are compared in Figure 14. Two thirds of the outbreaks in community systems were caused by deficiencies in treatment and distribution of water, whereas three fourths of the outbreaks in noncommunity systems were related to use of untreated groundwater or to poor treatment practices.

The overwhelming statistic gleaned from Figure 14 and Table 1 is that the 229 outbreaks in noncommunity systems were caused by use of untreated, contaminated groundwater or by inadequate or interrupted treatment. Disinfection is generally the only treatment provided in these systems. The 229 outbreaks represent nearly one half of all outbreaks reported for public water systems that are regulated by law; i.e., 237 outbreaks in community systems plus 296 in noncommunity systems equals 533 outbreaks, and 229/533 is approximately one half. If disinfection was in place where needed and applied properly, many outbreaks could be prevented. Some of the common problems that deserve attention from regulatory agencies and the water utility industry include:

1. Noncommunity systems suffer from lack of proper design, construction, and

TABLE 4

Comparison of community water systems providing treated and untreated surface water[7] in states with low and high outbreak rates

Outbreak Rate	State	Systems Providing Treated Surface Water	Systems Providing Untreated Surface Water
Low	Delaware	5	0
	Georgia	79	1
	Illinois	118	0
	Iowa	33	0
	Kansas	73	0
	Kentucky	127	3
	Louisiana	43	3
	Minnesota	23	0
	Mississippi	3	0
	Missouri	87	0
	Nebraska	3	0
	Nevada	9	0
	South Dakota	11	0
	Texas	166	6
	Utah	21	11
	Wisconsin	21	0
	Total*	822	24
High	Alaska	13	12
	Colorado	77	15
	Idaho	22	10
	Massachusetts	48	6
	New Hampshire	47	3
	New York	275	21
	Oregon	118	5
	Rhode Island	8	0
	South Carolina	63	0
	Vermont	21	11
	Wyoming	25	2
	Total†	717	85

*Low rate = 822/24 = 34.2
†High rate = 717/85 = 8.4

TABLE 5

Comparison of community water systems providing treated and untreated groundwater[7] in states with low and high outbreak rates

Outbreak Rate	State	Systems Providing Treated Groundwater	Systems Providing Untreated Groundwater	Ratio of Treated to Untreated Groundwater
Low	Delaware	22	13	1.6
	Georgia	155	171	0.9
	Illinois	575	211	2.7
	Iowa	387	272	1.4
	Kansas	399	1	399.0
	Kentucky	92	31	3.0
	Louisiana	112	123	0.9
	Minnesota	287	291	1.0
	Mississippi	123	107	1.1
	Missouri	150	191	0.8
	Nebraska	39	387	0.1
	Nevada	13	30	0.4
	South Dakota	75	148	0.53
	Texas	524	436	1.2
	Utah	68	181	0.4
	Wisconsin	217	173	1.3
	Total	3238	2767	*
High	Alaska	9	2	4.5
	Colorado	98	98	1.0
	Idaho	40	106	0.4
	Massachusetts	63	101	0.6
	New Hampshire	14	38	0.4
	New York	279	366	0.8
	Oregon	63	128	0.5
	Rhode Island	19	16	1.2
	South Carolina	49	99	0.5
	Vermont	10	105	0.1
	Wyoming	30	39	0.8
	Total	674	1098	†

*Median ratio = (1.0 + 1.1)/2 = 1.05
†Median ratio = 0.6

operation and receive minimal attention from regulatory agencies to correct these problems.

2. One microbiological sample is required during each quarter a noncommunity system is operational. A sample collected from the system during start-up after the off-season may not show the same results as one collected during heavy visitation and system overload.

3. Coliform samples that are collected periodically from a challenged system with problems and show negative results provide a false sense of security. Though it is easy to inactivate coliforms with chlorination, more resistant pathogens not detected by the testing procedure may survive.

4. The key to disinfection is reliability. Reliability is enhanced by yoked-up cylinders; switchover devices; auxiliary power; dosage applied in response to output; automatic residual recording; loop-controlled feed; adequate contact time; pH, temperature, and turbidity considerations; standby equipment or spare parts; and reports to substantiate operation.

A simple correction can often enhance reliability. For example, during investigation of a recent outbreak, examination of the chlorination facility showed that hypochlorite was pumped from a day tank in response to float operation in a reservoir. The operator duly noted in the record every day that the chlorine solution level in the day tank was "O.K." After an unsuccessful wait for the pump to cycle during the inspection, it was discovered that the electrical contacts in the relay box were so corroded that the pump was not receiving the signal. The solution to this problem was a simple correction in record-keeping: the recorded level of the chlorine solution would be used to indicate whether the pump was operating. It took only a few minutes for the operator to realize that if he regularly measured a 250–350-mm (10–12-in.) decrease in the solution level on a daily basis and suddenly found only a 75-mm (3-in.) decrease, something was wrong.

Cases of illness attributed to deficiencies in public water systems are shown in Figure 15 and are further classed according to community and noncommunity systems in Figure 16. Inadequate or interrupted treatment was responsible for the greatest number of cases of illness in community systems, whereas use of contaminated, untreated groundwater caused the most illness in noncommunity systems.

The states with low and high outbreak rates (Figure 5) were tabulated, and comparisons were made based on the source of water supply and treatment provided. The comparisons were limited to community water systems identified in the 1963 USPHS inventory. In Table 3, ratios of systems using groundwater

to those using surface water were computed for states with low and high outbreak rates, and the medians of the ratios were compared. The results indicate that water systems in states with a low outbreak rate depended more on groundwater than on surface water as a source of supply. This is a reasonable expectation in that groundwater generally has better microbiological quality than does surface water. This does present a conflict, however, in that more outbreaks are attributed to use of groundwater (for noncommunity systems). The conflict may be explained by the premise that community water systems are better operated, with disinfection in place where it is required.

Table 4 shows a comparison between states with low and high outbreak rates and the number of systems providing treated and untreated surface water. Treatment was defined in the 1963 USPHS inventory as "any action taken upon the water"; therefore, for example, communities that treated surface water with aeration were included. Comparison of the ratios indicates that states with a low rate of outbreaks had a much higher ratio of systems treating water to those not treating than did states that had a high rate of outbreaks. The fourfold difference in the ratios for low and high rates reinforces the need for adequate treatment of surface sources.

A similar comparison for the treatment of groundwater is shown in Table 5. Comparison of the ratios indicates more systems provided treatment of groundwater in the states with low outbreak rates.

Summary

In the 35-year period from 1946 to 1980, 672 waterborne disease outbreaks affecting more than 150 000 persons were reported. The increase in the annual occurrence of outbreaks that began in 1967 was probably due to better reporting from a few states. If this is true, the statistics for the United States during this 35-year period are greatly understated. The reporting of outbreaks is improving, if an increase in the number of outbreaks is used as an indicator. If the data for 1976–80 are used as an attainable level of sensitivity under the current reporting procedure, the average annual frequency of outbreaks is 38. Applying this value for annual occurrence to the 35-year period increases the period total to 1330 or nearly double the number reported. A similar analogy applied to illness shows a frequency of 10 000 cases per year, which applied to the 35-year period results in 350 000 cases of illness—considerably more cases than the number reported.

Clustering was evident when outbreaks in community systems were geographically distributed and rate-based according to the number of water systems in a respective state. Water systems in states with low outbreak rates were compared with those in states with high outbreak rates by using source of supply and treatment as indicators. Those states with low outbreak rates had a greater ratio of systems that depended on groundwater as a source of supply and that provided treatment of surface water and groundwater.

Outbreaks exhibit temporal distribution, with peak occurrences in June, July, and August. This distribution was more pronounced when outbreaks in community systems were compared with those in noncommunity systems. The number of outbreaks in noncommunity systems greatly exceeded those in community systems for the summer months. Noncommunity systems serve recreational areas that experience heavy visitation during the summer, causing maximum demand on water systems and overloads to sewerage-sewage facilities. Noncommunity systems suffer from design, construction, operation, and maintenance problems and normally receive less attention from regulatory agencies in terms of monitoring and inspection to correct the problems.

Although outbreaks in noncommunity systems outnumber those in community systems, the frequency of outbreaks is almost twice as great in community systems. However, outbreaks in noncommunity systems are more difficult to detect because they serve the traveler who may become ill 1600 km (1000 mi) from the point of exposure to contaminated drinking water and would not associate the illness with a place he visited two days earlier. Although underreporting of outbreaks occurs for community systems, it is thought to be a much more serious problem for noncommunity systems.

Cases of illness occurring in community water systems far outnumber those in noncommunity systems. Regulatory agencies should concentrate their efforts on protecting the source of water supply, ensuring adequate and reliable treatment, and improving distribution network practices in community systems to achieve the greatest overall reduction of waterborne illness.

Microbiological agents that cause waterborne outbreaks are rarely isolated from the water system. Investigators are more successful with identification of agents in specimens from cases where the agent is propagated and excreted in large numbers. For more than half of the outbreaks, no agent is identified, probably because of the lapse in time between occurrence of illness and the beginning of an investigation that includes collection of specimens.

The deficiencies in water systems that caused and contributed to waterborne outbreaks during this 35-year period differed little from those reported for the previous 26 years (1920–45). The glaring deficiencies were that disinfection was not in place where it was needed and not properly operated where it was in place. Changes in regulatory and industry approaches are indicated and may include scrutiny in approval, frequent inspection, operator training, and expanded monitoring from regulatory agencies with improvements in design, operation, and equipment from industry.

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